

PP polypropylene

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	polypropylene	
IUPAC name	-	poly(propene)	
CAS name	-	1-propene, homopolymer	
Acronym	-	PP	
CAS number	-	9003-07-0	
RETECS number	-	UD1842000	
Formula		$\left[\begin{array}{c} \text{CH}_2\text{CH} \\ \\ \text{CH}_3 \end{array} \right]_n$	
HISTORY			
Person to discover	-	Paul Hogan and Robert Banks	
Date	-	1951	
Details	-	Paul Hogan and Robert Banks obtained in laboratories of Phillips Petroleum "crystalline polypropylene"	
SYNTHESIS			
Monomer(s) structure	-	$\text{H}_2\text{C}=\text{CHCH}_3$	
Monomer(s) CAS number(s)	-	115-07-1	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	42.08	
Monomer(s) expected purity(ies)	%	99.2	
Monomer ratio	-	100% and less	
Formulation example	-	monomer(s), hydrogen (molecular mass control), catalyst	Maier, R-D; Bidell, Encyclopedia of Materials: Science & Technology, 7694-97, Elsevier, 2008.
Method of synthesis	-	gaseous propylene is polymerized under strict control of heat and pressure in the presence of catalyst; major polypropylene process technologies include slurry, bulk loop, stirred gas, fluid gas, and stirred bulk	Maier, C; Calafut, T, Polypropylene. The Definitive User's Guide and Databook, William Andrew, 1998.
Temperature of polymerization	°C	70 (bulk); 60-100 (gas-phase)	Maier, R-D; Bidell, Encyclopedia of Materials: Science & Technology, 7694-97, Elsevier, 2008.
Pressure of polymerization	MPa	3.-3.5 (bulk); 1-4.6 (gas-phase)	Maier, R-D; Bidell, Encyclopedia of Materials: Science & Technology, 7694-97, Elsevier, 2008.
Catalyst	-	morphology controlled Ziegler-Natta catalyst (Lynx)	
Mass average molecular weight, M_w	dalton, g/mol, amu	1,000-5,400,000	Maier, C; Calafut, T, Polypropylene. The Definitive User's Guide and Databook, William Andrew, 1998.
Polydispersity, M_w/M_n	-	1.1-5.5	
Polymerization degree (number of monomer units)	-	24-240,000	
Molar volume at 298K	cm ³ mol ⁻¹	calc.=49.5 (amorphous)	
Van der Waals volume	cm ³ mol ⁻¹	calc.=30.7 (amorphous)	
Radius of gyration	nm	11.3-41.3 (rapidly quenched); 14.8-47.7 (isothermally crystallized)	

PP polypropylene

PARAMETER	UNIT	VALUE	REFERENCES
Chain-end groups	-	unsaturated: vinylidene, i-butenyl, 2-butenyl, 4-butenyl; saturated: n-propyl, i-propyl, n-butyl, ethyl	Kawahara, N; Kojoh, S-I; Matsuo, S; Kaneko, H; Matsugi, T; Toda, Y; Mizuno, A; Kashiwa, N, Polymer, 45, 2883-88, 2004.
STRUCTURE			
Crystallinity	%	3.2-67	
Cell type (lattice)	-	orthorhombic (syndiotactic); monoclinic (isotactic)	
Cell dimensions	nm	orthorhombic (syndiotactic): a:b:c=1.45:1.12:0.74; monoclinic (isotactic): a:b:c=0.666:2.078:0.6495	
Unit cell angles	degree	99.62 (monoclinic)	
Number of chains per unit cell	-	2 (monoclinic); 2 (orthorhombic)	
Polymorphs	-	α (monoclinic), β (hexagonal)	Shieh, Y-T; Lee, M-S; Chen, S-A, Polymer, 42, 4439-48, 2001.
Tacticity	%	26 (rr, atactic); 32-67 (rr, semi-syndiotactic)	Sevegney, M S; Kannan, R M; Siedle, A R; Percha, P A, J. Polym. Sci. B, 43, 439-61, 2005.
Chain conformation	-	helix 3/1 (monoclinic, hexagonal)	Shieh, Y-T; Lee, M-S; Chen, S-A, Polymer, 42, 4439-48, 2001.
Entanglement molecular weight	dalton, g/mol, amu	7,050 (metallocene)	
Lamellae thickness	nm	7-13	Huang, W; Alamo, R G, Antec, 3546-50, 2000.
Crystallization temperature	°C	116-140	Shieh, Y-T; Lee, M-S; Chen, S-A, Polymer, 42, 4439-48, 2001; Naguib, H E; Xu, J X; Park, C B, Antec, paper 438, 2001.
Avrami constants, K/n	-	n=2.5-2.8	Shieh, Y-T; Lee, M-S; Chen, S-A, Polymer, 42, 4439-48, 2001.
COMMERCIAL POLYMERS			
Some manufacturers	-	DOW; ExxonMobile; Total	
Trade names	-	Polypropylene; Achive; Polypropylene	
PHYSICAL PROPERTIES			
Density at 20°C	g cm ⁻³	0.84-0.91; 0.97-1.33 (10-50% glass fiber); 0.98-1.25 (10-40% talc)	
Color	-	translucent to white to off-white	
Refractive index, 20°C	-	1.49-1.51	
Molar polarizability	cm ³ x 10 ⁻²⁵	6.1213	
Haze	%	14	
Gloss, 60°, Gardner (ASTM D523)	%	34-52	
Odor	-	may have acrid odor	
Melting temperature	°C	120-176; 147-158 (metallocene); 160-176 (monoclinic); 140-153 (hexagonal)	Shieh, Y-T; Lee, M-S; Chen, S-A, Polymer, 42, 4439-48, 2001; Cheng, C Y, Antec, 2019-2026, 1996.
Softening point	°C	155-161	
Decomposition onset temperature	°C	328	Patel, P; Hull, T R; McCabe, R W; Flath, D; Grasmeder, J; Percy, M, Polym. Deg. Stab., 95, 709-18, 2010.
Thermal expansion coefficient, 23-80°C	°C ⁻¹	1.05E-4	

PP polypropylene

PARAMETER	UNIT	VALUE	REFERENCES
Thermal conductivity, melt	W m ⁻¹ K ⁻¹	0.17-0.22	
Glass transition temperature	°C	calc.=-15; exp.=-8; -3.2 (isotactic); -9 to -51 (elastomeric)	
Specific heat capacity	J K ⁻¹ kg ⁻¹		
Heat of fusion	J g ⁻¹	209 (perfectly crystalline PP)	Fan, Y; Zhang, C; Xue, Y; Zhang, X; Ji, X; Bo, S, Polymer, 52, 557-63, 2011.
Maximum service temperature	°C	100	
Heat deflection temperature at 0.45 MPa	°C	85-107; 143-154 (10-50% glass fiber); 149 (10-50% glass fiber, chemically coupled)	
Heat deflection temperature at 1.8 MPa	°C	42-54; 93-121 (10-50% glass fiber); 113 (10-50% glass fiber, chemically coupled); 60-82 (10-40% talc)	
Vicat temperature VST/A/50	°C	138-155	
Vicat temperature VST/B/50	°C	82-96	
Hansen solubility parameters, δ_D , δ_P , δ_H	MPa ^{0.5}	17.7, 2.9, 1.2	
Interaction radius		6.2	
Hildebrand solubility parameter	MPa ^{0.5}	18.0-19.2	
Surface tension	mN m ⁻¹	20.4	
Dielectric constant at 100 Hz/1 MHz	-	2.2-2.6	
Dissipation factor at 100 Hz		0.0005	
Dissipation factor at 1 MHz		0.0005	
Volume resistivity	ohm-m	1E-12 to 1E-15; 9.6E1 (with 0.6 vol fraction of Ni coated mica)	Kandasubramanian, B; Gilbert, M, Macromol. Symp., 211, 185-95, 2005.
Shielding effectiveness	dB	20-28 (with 0.6 vol fraction of Ni-coated mica)	Kandasubramanian, B; Gilbert, M, Macromol. Symp., 211, 185-95, 2005.
Coefficient of friction	ASTM D1894	0.27-0.29 (chrome steel); 0.35-0.36 (aluminum)	Maldonado, J E, Antec, 3431-35, 1998.
Permeability to nitrogen, 25°C	cm ³ cm cm ⁻² s ⁻¹ Pa ⁻¹ x 10 ¹²	0.033	
Permeability to oxygen, 25°C	cm ³ cm cm ⁻² s ⁻¹ Pa ⁻¹ x 10 ¹²	0.17	
Permeability to water vapor, 25°C	cm ³ cm cm ⁻² s ⁻¹ Pa ⁻¹ x 10 ¹²	1.58	
Contact angle of water, 20°C	degree	94.9-107.3	
Surface free energy	mJ m ⁻²	30.2	
Speed of sound	m s ⁻¹	44.3-45.7	
Acoustic impedance		2.36-2.40	
Attenuation	dB cm ⁻¹ , 5 MHz	5.1-18.2	

PP polypropylene

PARAMETER	UNIT	VALUE	REFERENCES
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	26-32; 39-63 (10-50% glass fiber); 46-97 (10-50% glass fiber, chemically coupled); 30-33 (10-40% talc)	
Tensile modulus	MPa	1,700; 2,900-11,700 (10-50% glass fiber); 3,100-11,700 (10-50% glass fiber, chemically coupled); 2,550-5,200 (10-40% talc)	
Tensile stress at yield	MPa	31-35.2	
Elongation	%	10-140; 1-8.5 (10-50% glass fiber); 2.5-8 (10-50% glass fiber, chemically coupled); 10 (10-40% talc)	
Tensile yield strain	%	7-12	
Flexural strength	MPa	41; 56-98 (10-50% glass fiber); 66-150 (10-50% glass fiber, chemically coupled); 49-54 (10-40% talc)	
Flexural modulus	MPa	1,240-1,600; 2,100-8,900 (10-50% glass fiber); 2,400-8,900 (10-50% glass fiber, chemically coupled); 2,100-3,900 (10-40% talc)	
Compressive strength	MPa	40	
Young's modulus	MPa	1,200-2,000; 27,000 (fiber from ultrahigh molecular weight PP)	Chen, J; Si, X; Hu, S; Wang, Y; Wang, Y, J. Macromol. Sci. Eng., Part B, 47, 1, 192-200, 2008.
Izod impact strength, unnotched, 23°C	J m ⁻¹	1600; 190-480 (10-50% glass fiber); 530-640 (10-50% glass fiber, chemically coupled); 370-1,175 (10-40% talc)	
Izod impact strength, notched, 23°C	J m ⁻¹	18-69; 37-53 (10-50% glass fiber); 80-110 (10-50% glass fiber, chemically coupled); 43-59 (10-40% talc)	
Tenacity (fiber) (standard atmosphere)	cN tex ⁻¹ (daN mm ⁻²)	15-60	Fourne, F, Synthetic Fibers. Machines and Equipment Manufacture, Properties. Carl Hanser Verlag, 1999.
Tenacity (wet fiber, as % of dry strength)	%	100	Fourne, F, Synthetic Fibers. Machines and Equipment Manufacture, Properties. Carl Hanser Verlag, 1999.
Fineness of fiber (titer)	dtex	1.5-40	Fourne, F, Synthetic Fibers. Machines and Equipment Manufacture, Properties. Carl Hanser Verlag, 1999.
Length (elemental fiber)	mm	38-200	Fourne, F, Synthetic Fibers. Machines and Equipment Manufacture, Properties. Carl Hanser Verlag, 1999.
Shore A hardness	-	64-90 (elastomeric)	Myers, C; Allen, C; Ernst, A; Naim, H, Antec, 2050-55, 1999.
Rockwell hardness	-	R102-103	
Shrinkage	%	0.72-2; 0.1-0.8 (10-50% glass fiber); 0.7-1.6 (10-40% talc)	Chang, T C; Faison, E, Polym. Eng. Sci., 41, 5, 703-10, 2001.
Intrinsic viscosity, 25°C	dl g ⁻¹	1.12-1.87	
Melt viscosity, shear rate=100 s⁻¹	Pa s	100	
Melt volume flow rate (ISO 1133, procedure B), 230°C/2.16 kg	cm ³ /10 min	4-26	
Pressure coefficient of melt viscosity, b	G Pa ⁻¹	20.5	Aho, J; Syrjala, S, J. Appl. Polym. Sci., 117, 1076-84, 2010.
Melt index, 230°C/2.16 kg	g/10 min	0.3-40	
Water absorption, equilibrium in water at 23°C	%	0.02-0.04	
CHEMICAL RESISTANCE			
Acid dilute/concentrated	-	very good	

PP polypropylene

PARAMETER	UNIT	VALUE	REFERENCES
Alcohols	-	very good	
Alkalis	-	very good	
Aliphatic hydrocarbons	-	fair to poor	
Aromatic hydrocarbons	-	poor	
Esters	-	fair	
Greases & oils	-	good to fair	
Halogenated hydrocarbons	-	poor	
Ketones	-	good	
⊖ solvents	-	i-amyl acetate, i-butyl acetate, cyclohexanone, diphenyl ether	
Good solvent	-	chlorinated hydrocarbons, cyclohexane, diethyl ether, toluene	
Non-solvent	-	many polar solvents	
Effect of EtOH sterilization (tensile strength retention)	%	100 to 106	Navarrete, L; Hermanson, N, Antec, 2807-18, 1996.
FLAMMABILITY			
Ignition temperature	°C	>200; 93.3 (fibers & yarns)	
Autoignition temperature	°C	570	
Limiting oxygen index	% O ₂	17-19	
Minimum ignition energy	J	0.03	
Heat release	kW m ⁻²	101-727 (with flame retardants)	Yu, B; Liu, M; Lu, L; Dong, X; Gao, W; Tang, K, Fire Mater., 34, 251-61, 2010.
Char at 500°C	%	0	Lyon, R E; Walters, R N, J. Anal. Appl. Pyrolysis, 71, 27-46, 2004.
Heat of combustion	J g ⁻¹	45,800	Walters, R N; Hacket, S M; Lyon, R E, Fire Mater., 24, 5, 245-52, 2000.
Volatile products of combustion	-	CO, CO ₂ , soot	
CO yield	%	5-16 (with flame retardants)	Yu, B; Liu, M; Lu, L; Dong, X; Gao, W; Tang, K, Fire Mater., 34, 251-61, 2010.
UL rating	-	HB; V-0 (flame retarded grades)	
WEATHER STABILITY			
Spectral sensitivity	nm	320-360; 300-350	
Activation wavelengths	nm	310, 300-350	
Excitation wavelengths	nm	230, 283, 287, 290, 295, 323, 330 (thermally degraded film); 230, 270, 285, 290, 330	
Emission wavelengths	nm	295, 320-330, 332, 340, 342, 400, 430, 470, 480, 520 (thermally degraded film); 309, 320, 420, 445, 480, 510	
Depth of UV penetration	μm	100	
Important initiators and accelerators	-	unsaturations, aromatic carbonyl compounds (deoxyanisoin, dibenzocycloheptadienone, flavone, 4-methoxybenzophenone, 10-thioxanthone), hydrogen bound to tertiary carbon at branching points, aromatic amines, groups formed on oxidation (hydroperoxides, carbonyl, carboxyl, hydroxyl) substituted benzophenones, complexes with ground-state oxygen, quinones (anthraquinone, 2-chloroanthraquinone, 2-tert-butylanthraquinone, 1-methoxyanthraquinone, 2-ethylanthraquinone, 2-methylanthraquinone), transition metal compounds (Ni < Zn < Fe < Co), ferrocene derivatives, titanium dioxide (anatase), ferric stearate, polynuclear aromatic compounds (anthracene, phenanthrene, pyrene, naphthalene, titanium polymerization catalyst	

PARAMETER	UNIT	VALUE	REFERENCES
Products of degradation	-	free radicals, hydroperoxides, carbonyl groups, chain scissions, crosslinks	
Stabilizers	-	UVA: phenol, 2-(5-chloro-2H-benzotriazole-2-yl)-6-(1,1-dimethylethyl)-4-methyl-; 2-(2H-benzotriazole-2-yl)-4,6-di-tert-pentylphenol; 2-(2H-benzotriazole-2-yl)-4-(1,1,3,3-tetraethylbutyl)phenol; 2-(2H-benzotriazole-2-yl)-4,6-bis(1-methyl-1-phenylethyl)phenol; 2,2'-methylene-bis(6-(2H-benzotriazole-2-yl)-4-1,1,3,3-tetramethylbutyl)phenol; 2-(2H-benzotriazole-2-yl)-6-dodecyl-4-methylphenol, branched & linear; 2,4-di-tert-butyl-6-(5-chloro-2H-benzotriazole-2-yl)-phenol; 2-[4,6-bis(2,4-dimethylphenyl)-1,3,5-triazin-2-yl]-5-(octyloxy)phenol; Screener: titanium dioxide, zinc oxide, carbon black; Acid neutralizer: hydrotalcite; Fiber: carbon nanotubes; HAS: 1,3,5-triazine-2,4,6-triamine, N,N''[1,2-ethanediy-bis[[[4,6-bis[butyl(1,2,6,6-pentamethyl-4-piperidinyl)amino]-1,3,5-triazine-2-yl]imino]-3,1-propanediyl]]bis[N',N''-dibutyl-N',N''-bis(1,2,2,6,6-pentamethyl-4-piperidinyl)-; bis(2,2,6,6-tetramethyl-4-piperidyl) sebacate; 2,2,6,6-tetramethyl-4-piperidinyl stearate; N,N'-bisformyl-N,N'-bis-(2,2,6,6-tetramethyl-4-piperidinyl)-hexamethylenediamine; reaction products of N,N'-ethane-1,2-diylbis(1,3-propanediamine), cyclohexane, peroxidized 4-butylamino-2,2,6,6-tetramethylpiperidine and trichloro-1,3,5-triazine; poly[[[6-[1,1,3,3-tetramethylbutyl)amino]-1,3,5-triazine-2,4-diyl][2,2,6,6-tetramethyl-4-piperidinyl]imino]-1,6-hexanediyl[2,2,6,6-tetramethyl-4-piperidinyl]imino]; 1,6-hexanediamine-N,N'-bis(2,2,6,6-tetramethyl-4-piperidinyl)-polymer with 2,4,6-trichloro-1,3,5-triazine, reaction products with N-butyl-1-butanamine an N-butyl-2,2,6,6-tetramethyl-4-piperidinamine; butanedioic acid, dimethylester, polymer with 4-hydroxy-2,2,6,6-tetramethyl-1-piperidine ethanol; 1, 6-hexanediamine, N, N'-bis(2,2,6,6-tetramethyl-4-piperidinyl)-, polymers with 2,4-dichloro-6-(4-morpholinyl)-1,3,5-triazine; 1,6-hexanediamine, N,N'-bis(2,2,6,6-tetramethyl-4-piperidinyl)-, polymers with morpholine-2,4,6-trichloro-1,3,5-triazine reaction products, methylated; Phenolic antioxidant: 2,6-di-tert-butyl-4-(4,6-bis(octylthio)-1,3,5-triazine-2-ylamino)phenol; pentaerythritol tetrakis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate); octadecyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl)-propionate; 3,3',3',5,5',5'-hexa-tert-butyl-a,a',a'-(mesitylene-2,4,6-triyl)tri-p-cresol; 2-(1,1-dimethylethyl)-6-[[3-(1,1-dimethylethyl)-2-hydroxy-5-methylphenyl]methyl-4-methylphenyl acrylate; 1,3,5-tris(3,5-di-tert-butyl-4-hydroxybenzyl)-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione; 2',3-bis[[3-[3,5-di-tert-butyl-4-hydroxyphenyl]propionyl]]propionohydrazide; ethylene bis[3,3-bis[3-(1,1-dimethylethyl)-4-hydroxyphenyl]butanoate]; 1,3,5-tris(4-tert-butyl-3-hydroxy-2,6-dimethylbenzyl)-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione; 2,2'-methylenebis(4-methyl-6-tertbutylphenol); 1,1,3-tris(2'methyl-4'-hydroxy-5'tert-butylphenyl)butane; Phosphites: bis-(2,4-di-t-butylphenol) pentaerythritol diphosphite; tris (2,4-di-tert-butylphenyl) phosphite; distearyl pentaerythritol diphosphite; trilauryl trithiophosphite; Quencher: (2,2'-thiobis(4-tert-octylphenolato))-N-butylamine-nickel(II); Optical brightener: 2,2'-(2,5-thiophenediyl)bis(5-tert-butylbenzoxazole); 2,2'-(1,2-ethylenediyl)-4,1-phenylene)bisbenzoxazole	
Effect of exposure		cracks are formed after 228 h in Xenotest	
BIODEGRADATION			
Colonized products		construction materials, membranes, thin films	
Typical biodegradants	-	formation of hydroperoxides which destabilize the polymeric carbon chain to form a carbonyl group	

PP polypropylene

PARAMETER	UNIT	VALUE	REFERENCES
Stabilizers	-	1, 2-benzisothiazolin-3-one, N-halamine precursor, silver nanoparticles, silver powder, TiO ₂ -anatase; surface functionalization	Yao, F; Fu, G-D; Zhao, J; Kang, E-T; Neoh, K G, J. Membrane Sci., 319, 1-2, 149-57, 2008.
TOXICITY			
NFPA: Health, Flammability, Reactivity rating	-	1/1/0	
Carcinogenic effect	-	not listed by ACGIH, NIOSH, NTP	
Mutagenic effect	-	not known	
Teratogenic effect	-	not known	
Reproductive toxicity	-	not known	
TLV, ACGIH	mg m ⁻³	3 (respiratory), 10 (total)	
OSHA	mg m ⁻³	5 (respiratory), 15 (total)	
Oral rat, LD₅₀	mg kg ⁻¹	>5,000	
Skin rabbit, LD₅₀	mg kg ⁻¹	>2,000	
ENVIRONMENTAL IMPACT			
Aquatic toxicity, Daphnia magna, EC₅₀* 48 h	mg l ⁻¹	3,000-75,000	Lithner, Ph D Thesis, Univrsity of Gothenburg, 2011.
Cradle to grave non-renewable energy use	MJ/kg	65-72	
Cradle to pellet greenhouse gasses	kg CO ₂ kg ⁻¹ resin	1.5-2.0	
Life cycle value analysis	mPt	85 (the same part from aluminum - 96)	Ibeh, C C; Bhattarai, D, Antec, 2858-61, 2003.
PROCESSING			
Typical processing methods	-	blow molding, extrusion, injection molding, injection-stretch blow molding, thermoforming	
Preprocess drying: temperature/ time/residual moisture	°C/h/%	79/2	
Processing temperature	°C	191-250	
Processing pressure	MPa	69-103 (injection); 8 (back); 49 (holding)	
Additives used in final products	-	Fillers: aluminum flakes, antimony trioxide, barium sulfate, bismuth carbonate, calcium carbonate, calcium sulfate, carbon black, carbon nanotube, clay, fly ash, glass beads, glass fiber, glass flakes, hydromagnesite-huntite, hydrotalcite, magnesium hydroxide, metal powders (aluminum, iron, nickel), mica, montmorillonite, nano-calcium carbonate, phenolic microspheres, poly(alkylene terephthalate) fiber, potassium-magnesium aluminosilicate, red phosphorus, sepiolite, silica flour, silicium carbide, silver powder, stainless steel fiber, talc, wollastonite, wood fiber and flour, zinc borate; Plasticizers: dioctyl sebacate, glycerin, paraffinic oil, isooctyl tallate, paraffinic, naphthenic, and aromatic processing oils, polybutenes; Antistatics: alkyl-bis(2-hydroxyethyl)amine, carbon nanotubes, glycerol monostearate, lauric diethanol amide, N,N-bis(2-hydroxyethyl) alkoxypropylbetaine, polypyrrole, stearyldiethanolamine; Antiblocking: calcium carbonate, crosslinked silicone spheres, diatomaceous earth, natural silica, synthetic silica; Release: calcium stearate, glyceryl monostearate; Slip: behenamide, erucamide, N,N'-bisethylene oleamide, oleamide, silicone oil	

PP polypropylene

PARAMETER	UNIT	VALUE	REFERENCES
Applications	-	automotive, electrical components, fibers, furniture, packaging, tapes, many other applications, such as for example, mechanical lungs, orthopedic bandages, sutures	
Outstanding properties	-	sterilizable (autoclave and ethylene oxide), low extractables	
BLENDS			
Suitable polymers	-	EOC, EPDM, PA6, PANI, PE, PCL, PHB, PPy, PS, SEBS	
ANALYSIS			
FTIR (wavenumber-assignment)	cm ⁻¹ /-	degradation products: hydroxyl – 3600-3200; carbonyl – 1800-1700; ketone – 1725-15; carboxylic acid – 1712-1705, vinyl – 909	Rajakumar, K; Sarasvathy, V; Thamarai Chelvan, A; Chitra, R; Vijayakumar, C T, J. Polym. Environ., 17, 191-202, 2009.
NMR (chemical shifts)	ppm	pentad structure determination	Harding, G W; van Reenen, Eur. Polym. J., 47, 1, 70-77, 2011.
x-ray diffraction peaks	degree	effect of UV exposure on crystallinity retention	Wanasekara, N; Chalivendra, V; Calvert, P, Polym. Deg. Stab., 96, 4, 432-37, 2011.